

A NEW APPLICATION OF THE HYBRID PAVEMENT TO THE AGED CONCRETE PAVEMENT OF CHUO EXPRESSWAY

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1. Preface

Hachioji branch of the Central Nippon Expressway Company Limited manages about 305km expressway networks between the Takaido IC and Ihoku IC of Chuo Expressway. Of these, concrete pavement is constructed between Nirasaki IC and Suwaminami IC, approximately 36kilometers. (Figure 1)

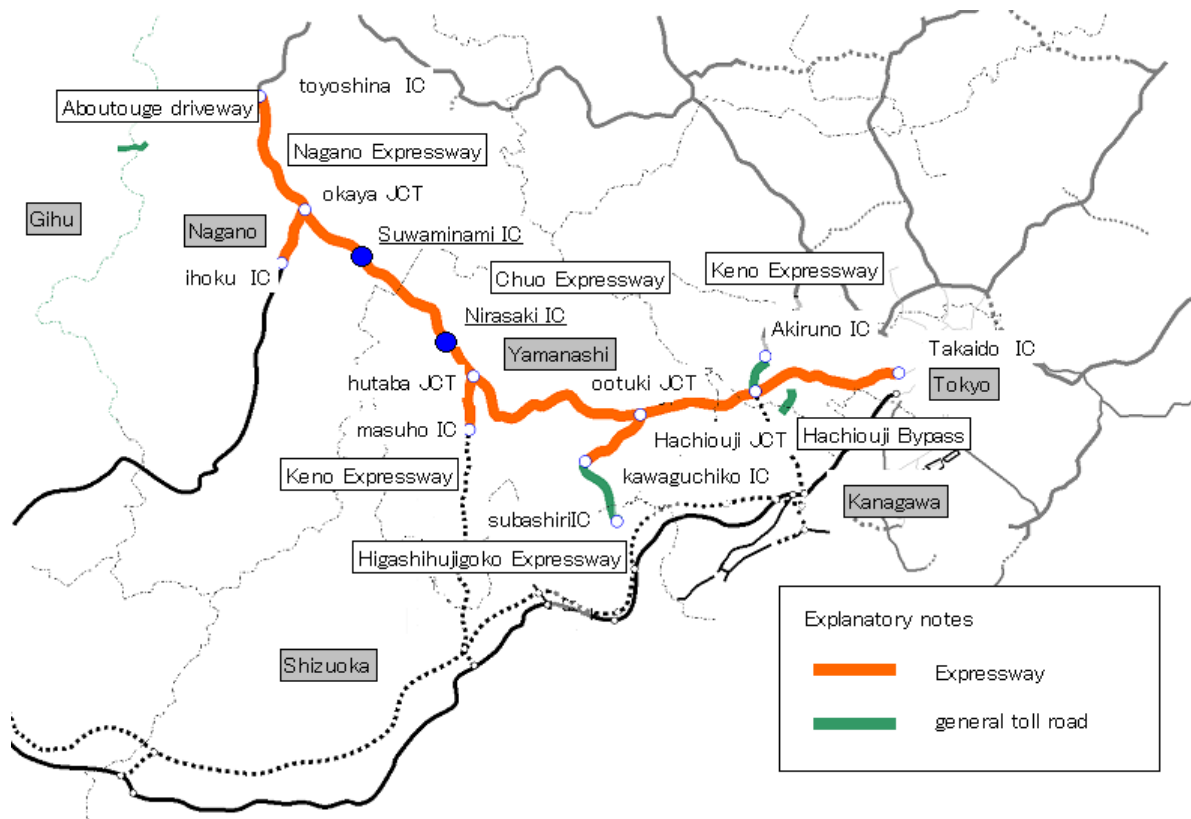


Figure 1: The position figure of the Hachioji branch office

Over 30 years has passed since this section opened. Therefore, the damages of crack and faulting of joint are occurred on pavement slabs. (Figure 2 and Figure 3)

As a result, traveling performance is deteriorates by outbreak of traffic vibration and noise remarkably, and early remediation of the section concerned becomes the important problem.

This paper reports the efficiency of the hybrid pavement.



Figure 2: The outbreak situation of the crack



Figure 3: The outbreak situation of the faulting of joint

2. A property for concrete pavement

Figure 4 shows typical cross-section of the concrete pavement. Roadway area and side margin strip are concrete pavement, and shoulder is the asphalt pavement.

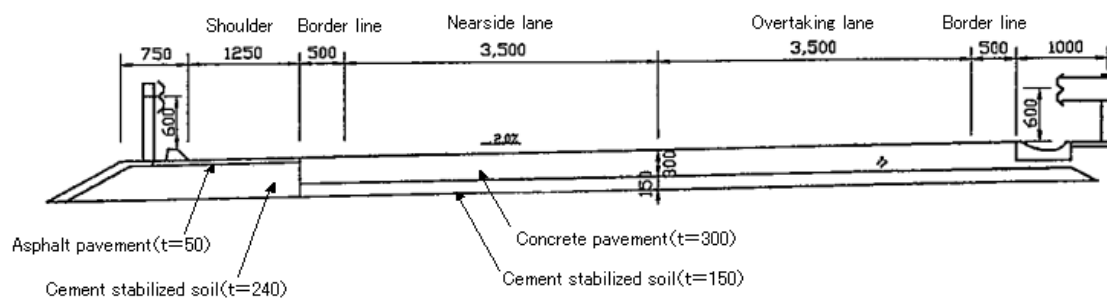


Figure 4: Typical cross-section of the concrete

The concrete pavement section has been damaged because of aged deterioration, such as partially cracks but is still soundness.

However, the deteriorating situation has reduced the service level.

Table 1 shows that a road surface property, and Figure 5 shows the IRI value (International Roughness Index) of the existing concrete pavement.

The concrete pavement is a state good in total, but over 20mm rutting is seen in the point partially.

IRI value is 2.2 mm/m on the average of the concrete pavement section It is 1.8 mm/m on the average of the asphalt pavement section. In addition, the point more than 4.0mm/m was confirmed partially, too.

According to the result of a rideability examination performed in the past, 2.2 mm /m is the same level as road condition in which more than 50% of the subject begin to feel worse.

Table 1:The road surface property pavement

Division	traffic lane	rutting (mm)		I R I (mm/m)	
		average	maximum	average	maximum
up line	nearside lane	12.6	19.0	2.35	3.8
	overtaking lane	4.5	15.0	2.00	3.8
down line	nearside lane	10.9	23.0	2.29	4.0
	overtaking lane	3.9	16.0	2.05	3.6

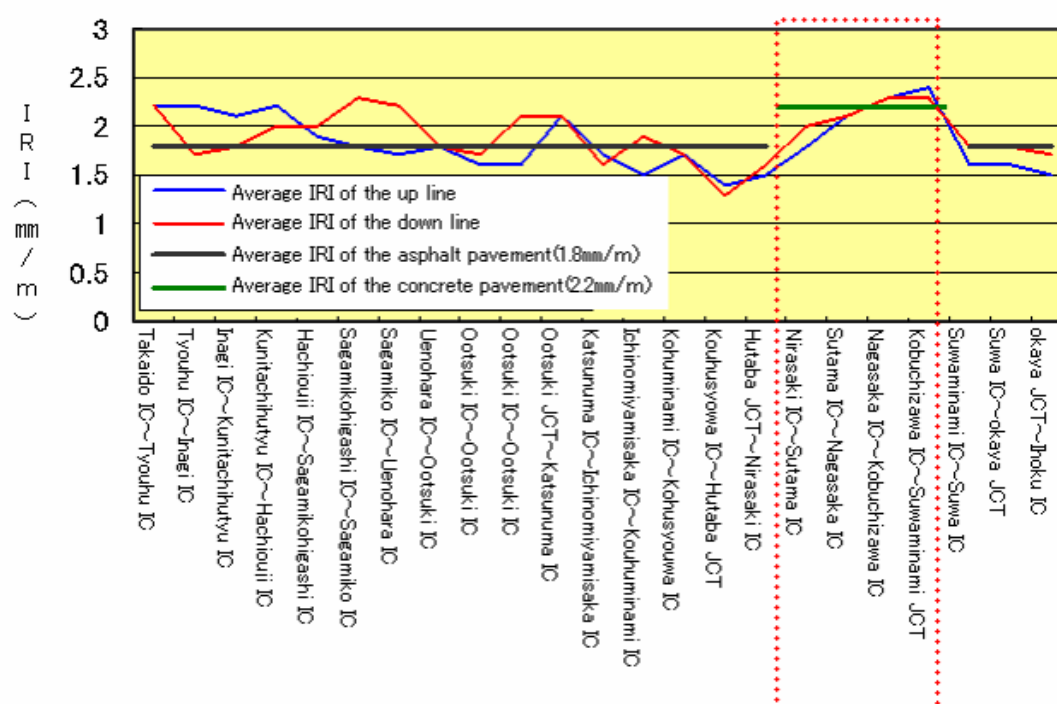


Figure 4: IRI according to IC section

3. The development of the improvement plan

3-1 A plan summary

The Hachioji branch set up a concrete pavement improvement technology deliberation committee by the expert from 2000. The committee performed repair of the concrete pavement and technical deliberation about the overlay by the asphalt pavement.

As a result of investigation among committees from 2000 to 2003, a structure state of concrete pavement was comparatively soundness.

The experts judged that it is necessary to improve the damaged road surface, and early overlays and maintenance of soundness of the concrete pavement were adopted.

The porous asphalt pavement was necessary in order to respond diversification of needs in the road structures, and an overlay by the asphalt pavement of 8cm consisting of two laminar structure of the high quality pavement(4cm) + stone mastic asphalt(4cm) with a basic policy were established.

<<Short-term measures>>

- 1) Rutting, Skid resistance : When early correspondence is necessary , steelblast must be carried out.
- 2) Crack : Barstich and impregnation must be carried out. (Barstich is the way to connect pavement slab with a round steel.)
- 3) The deficit of the joint : Under ceiling and barstich must be carried out.

<<The middle, long-term measures>>

- 4) Rutting, Crack : These must be repaired with a high quality pavement, and this improvement is suitable for a plan in the future. An intermediate course of the pavement is composed of stone mastic asphalt.

3-2 A plan for the early improvement of traveling performance

Based on a basic policy by the committee, the examination of a new method of construction was came up with in order to realize the efficiently early maintenance on the limited budget.

The choice of the method of construction was demanded not to deviate from the improvement policy (high quality pavement + stone mastic asphalt) that the committee adopted.

Therefore, the possibility of hybrid pavement with hybrid mixture is examined between Nirasaki IC and Kobuchisawa IC ($L \approx 24$ km) because a road surface property of this section is better than that of other section between Nirasaki IC and Suwaminami IC ($L \approx 36$ km).

Figure 5 shows location map of execution.

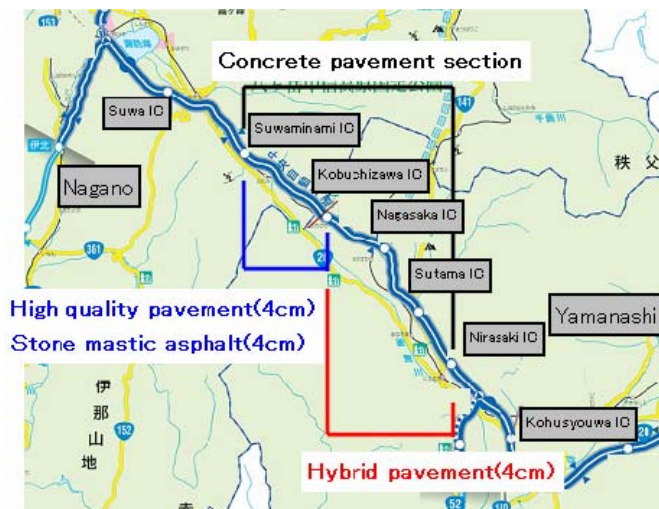


Figure 5: Location map of execution

The hybrid mixture, has a dense structure and an open surface texture, because asphalt sinks in the lower layer with progress in time of rolling compaction. The hybrid mixture provides a safe driving without skid and splash on rainy days, reducing the traffic noise, and improvement in visibility. Furthermore, the hybrid pavement has good performance; fluidity resistance, wear resistance, and aggregate litter control. A road surface can secure necessary performance by adopting this hybrid pavement. Therefore, the hybrid pavement is applied in order to improve the concrete pavement. Figure 6 shows diagrammatic illustration of hybrid pavement.

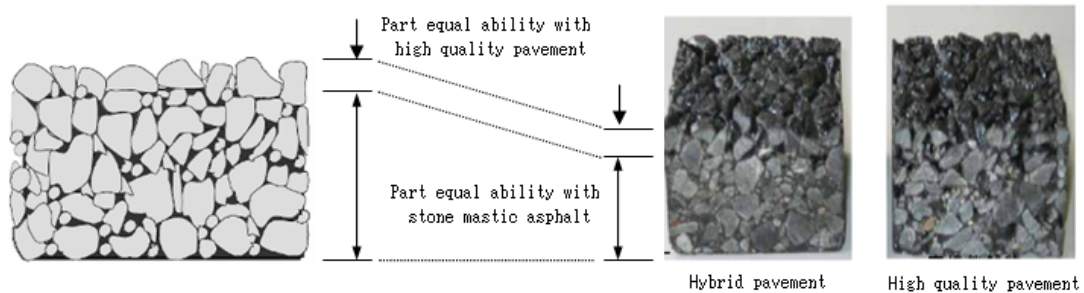


Figure 6: Diagrammatic illustration of hybrid pavement

3-3 Repair of existing concrete pavement

Previous repair of existing concrete pavement is more important, because the surface layer of hybrid pavement is apt to be effected by roughness of the existing concrete pavement.

The committee decided on repair of the joint of the concrete pavement with barstich. The existing slip bar is expected damage if load transmissibility becomes less than 65% from past examples. Therefore, a field investigation was carried out about a point of 42%, 64%, and 82%.

As a result, four slip bars among five were broken in 42% and 64% point of load transmissibility. On the other hand, one slip bar was broken in 82% and 77%.

As a result of this field investigation, barstich is adopted the existing concrete pavement whose load transmissibility is less than 70%. (Figure 7 and Figure 8 and Figure 9)

When deflection volume of the concrete pavement is more than 0.4mm, a cavity is expected to exist under concrete pavement. Therefore, a repair of the cavity is used by asphalt impregnation.

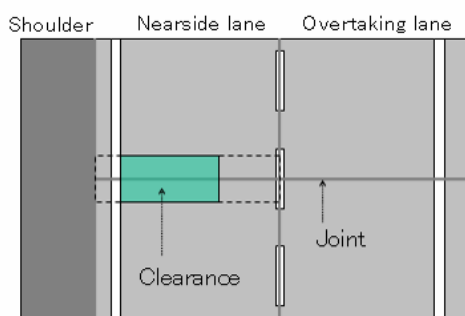


Figure 7: Location map of field investigation

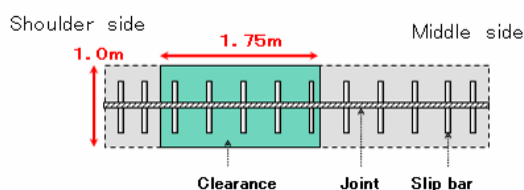


Figure 8: Arrangement of slip bar



Figure 9: Subsidiary fracture of slip bar

3-4 Examination about the adoption of the hybrid pavement

In order to decide the improvement policy by hybrid pavement after 2007, binder classification of hybrid mixture was decided by undertake construction it in 2006. Several undertake construction was carried out between Nirasaki IC and Sudama IC; some kinds of impregnations and some thickness of pavement. The test pavement was evaluated by a follow-up survey after six months.

<Binder materials>

The indoor and outdoor examination of high improved and high viscosity modified binder was carried out in order to decide the most effective binder. Table.2 shows that the evaluation of high improved and high viscosity modified binder was satisfied a standard value in the indoor examination.

Table 2: tabulated list of the standard test result

Test term			Average level		Test result	
					OAC:5.6%	
			High improved and high	Viscosity modified binder	High improved and high	Viscosity modified binder
Mixing temperature			—	—	175°C~185°C	170°C~180°C
Marshall test	Voids of mineral aggregate:VMA(%)		Less than 20.2	Less than 20.2	18.9	18.8
	Degree of saturation(%)		64.0~69.5	64.0~69.5	68.3	68.6
	Percentage of void (%)	Vacuum packaging	5.8~7.1	5.8~7.1	6.0	5.9
		Apparent	2.5~2.8	2.5~2.8	2.6	2.6
	stability (KN)		More than 6.0	More than 6.0	11.1	9.0
	stability /flow value (KN/m)		2,000~6,000	2,000~6,000	2,783	3,608
Cantabro test	Loss factor of cantabro(%)		More than 6.0	More than 6.0	3.4	3.8
Wheel tracking test	Resistance to flow		6,000turned/mm	3,000turned/mm	9,500	7,960
Pressurization permeability test			Less than 1×10^{-7}	Less than 1×10^{-7}	impervious	impervious
Bending test			More than 6.0	More than 6.0	8.3	7.13
Wheel tracking test of immersion in water	Resistance to pull-out type fracture		—	Less than 5%	—	2.6

The hybrid mixture is divided to two levels when time passes, and the transportation time was estimated about 70 minutes on the construction of the expressway. Therefore, the examination was to investigate the effect the transportation time.

The result of the test pavement with high improved binder had run-off of asphalt and flush.



Figure 10: Test pavement (Viscosity modified binder)



Figure 11: Test pavement (High improved and high)



Figure 12: Road surface (Viscosity modified binder)



Figure 13: Road surface (High improved and high)

The hybrid mixture with high viscosity modified binder were adopted as the pavement of the construction in 2006 and in 2007, because high viscosity modified binder was stable qualitatively and satisfied a standard value. Table 3 shows that a combination of mixture in 2008 was modified form one in 2007. Furthermore, the transportation time was shortened from about 70 minutes to about 30 ~ 40. As a result, high improved binder became available for the hybrid mixture. The execution costs decreased, and were able to widen possibility of the hybrid pavement.

Table 3: Revision composition of hybrid mixture

Opening of sieve (mm)	Conventional gradation (%)	Change gradation (%)
13.2	95~100	95~100
9.5	—	—
4.75	28~32	30~38
2.36	22~25	22~27
0.6	18~20	17~21
0.3	12~17	15~18
0.15	10~13	10~13
0.175	8~10	9~11
asphalt content	5.6%	5.4%

<Reflective cracking measures of the joints>

Before overlaying, it is important for the joints of concrete pavement to prevent reflective cracking.

Setting up cutting joint (30mm in depth and 3mm in width) for second layer of overlay is more effective from current experience. However the influence by the rainwater to penetrate into joints of first layer of hybrid pavement is apprehended.

Figure 14 shows the comparison to install three kinds of materials with different elastic strength asphalt injection material that prevent from penetration of rainwater and corner cracks of concrete pavement by trial field.

As a result of the trial, the injection material on real fields does not needed so far, therefore there are no change.

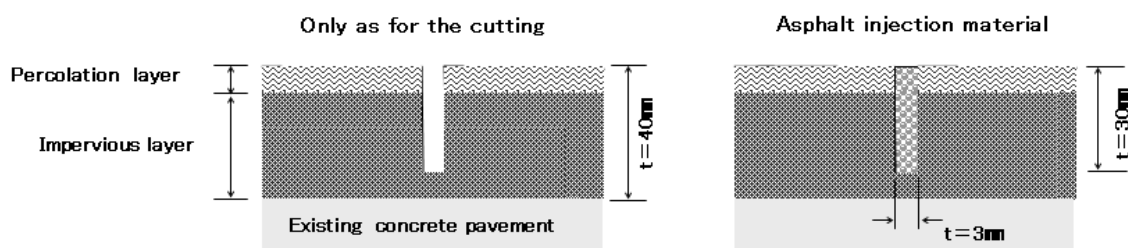


Figure 14: Diagrammatic illustration of joint

<Thickness of the hybrid pavement>

Four centimeter of thickness appropriates for hybrid pavement in general. However, various types of thickness of hybrid pavements were tested so that the optimum thickness and durability of the pavement and aging of reflective cracking was needed to confirm. Overlay for four or five centimeter of thickness and five centimeter after milling one centimeter concrete pavement were executed by this follow-up (Figure 15).

As a result of the follow-up, there are no changes of the surface property and damages by reflective cracking between four and five centimeters of thickness.

Figure 16 shows the IRI improves the average from 2.1mm/m to 1.7mm/m. However there remains wobble vibration at the joints by the major impact of thin thickness of hybrid pavement.

The repair of concrete pavement using hybrid pavement has been carried on a full-scale operation from 2007 so that there are almost no problems for overlay of the hybrid pavement on the concrete pavement by one layer as the result.

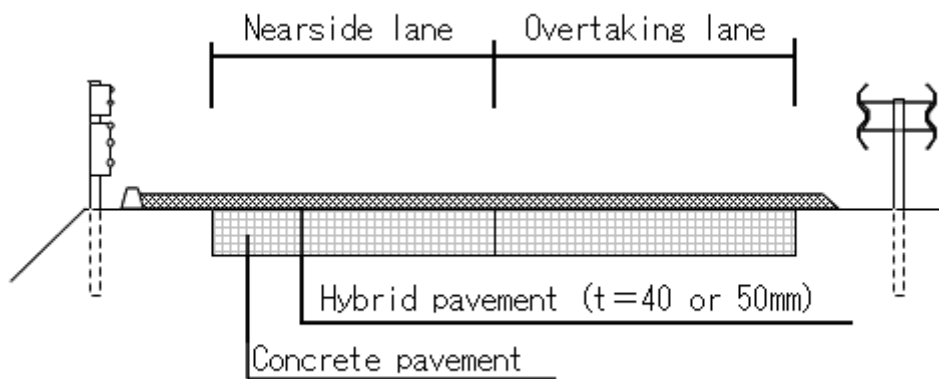


Figure 15: Diagrammatic illustration of thickness of pavement

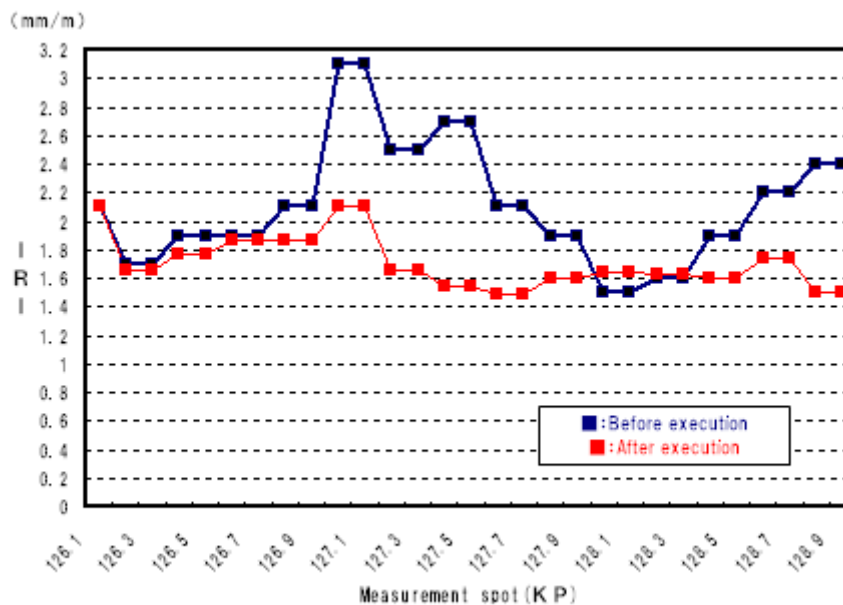


Figure 16: Examination execution result (IRI)

4. The overlay on hybrid pavement

(1) The decision of the improvement policy

From the results of examination in 2006, improvement policy using hybrid pavement on concrete pavement between Nirasaki IC and Kobuchisawa IC from 2007 is determined as follows,

- 1) Four centimeter of thickness of hybrid pavement in basis,
- 2) No need for impregnation method to the cutting joint,
- 3) Repair by the barstitch less than 70 percent of load transmission rate, and
- 4) Carrying out the asphalt impregnation method more than 0.4mm of deflection.

(2) The result of execution in 2007

Figure 17 shows the result of IRI after the execution.

Homogeneous result was confirmed in about the execution in 2007, although there seemed unevenness on IRI value because of the impact of differences in level of existing concrete pavement. by the examination execution of 2006

The sensor of asphalt finisher could move more smoothly because slope was prepositioned using mold form after difference of joints were figured out by beforehand survey in 2007 (Figure 18).

(3) The result of execution in 2008

10 kilometer length of improvement were executed in 2008. In this time, the difference of joints measure to scrape down them was adopted. This was more suitable than before. By this execution, efficiency of work and the evenness were moreover improved.

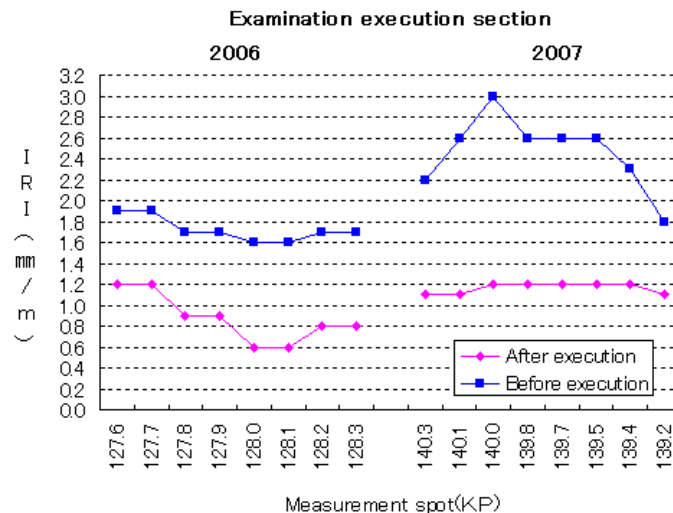
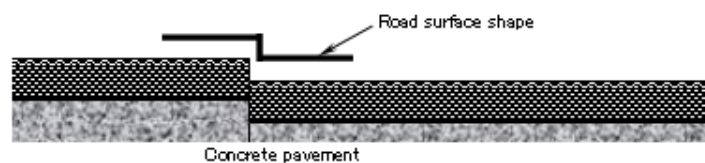


Figure 17: Execution result of 2006 .2007 year (IRI)

【Execution method(2006)】



【Execution method(2007)】

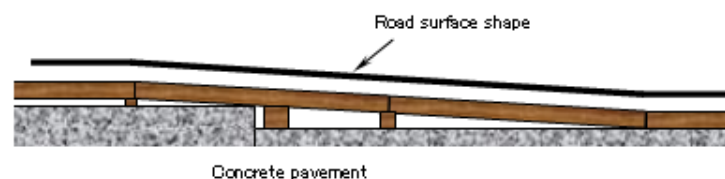
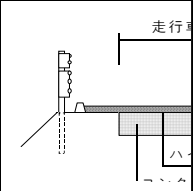


Figure 18: Improvement situation of the road surface shape



5 Conclusion

In this repair section, safety of drivers must be insured and short-term construction is necessary. In this situation, the hybrid pavement is the most effective method, because it is low cost and an overlay can execute the work with only 1 layer.

Thickness of hybrid pavement was weak point for the first time. It was effected by concrete pavement. As a result, some points at the joints occur minute vibration in driving.

Performance and the effectiveness of the hybrid pavement is confirmed with some examinations and improvements of construction.

Two years has passed from examination execution of the hybrid pavement. However, the damage of the pavement is not confirmed, and the road surface property is still soundly.

The completion for repair of the concrete pavement section on the Chuo Expressway is in 2009. it was advanced one year from 2010 in order to give more serviceability to drivers.

After the improvement of this section, the road surface property will be investigated, and traveling performance will be evaluated.

I thank the committee for giving grant advice about concrete pavement improvement technology, and the TAKENAKA Road Construction Co.,LTD. ,Taisei Rotec Corporation, and KAJIMAROAD Co., Ltd, for construction this section,

(bibliography)

- 1) kazuhiko kumada, keizou kamiya, sigeru simeno: The examination about the general evaluation technique of the road surface which paid its attention to traveling performance, pavement, Vol.43,pp27~30(2008.7)